North Saskatchewan River Water Quality 1970~1981

Alberta

ENVIRONMENT

Pollution Control Division

Water Quality Control Branch

NORTH SASKATCHEWAN RIVER WATER QUALITY

1970 - 1981

ALBERTA ENVIRONMENT

POLLUTION CONTROL DIVISION

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ABSTRACT

Long-term trends in water quality are described for four stations on the North Saskatchewan River over the period 1970 to 1981. The relative effects of natural and anthropogenic (particularly from the City of Edmonton) factors, accounting for longitudinal changes in water quality in the river, have been quantified.

General increases in some major ions were recorded. It is concluded that the increases are due to natural erosion and weathering processes along the length of the river. The major effects from development appear to be from the Edmonton region and are of an organic nature, which can be attributed to municipal effluents. These are increases in the nutrients, forms of phosphorus and nitrogen, and the microbiological indicators of water quality, total and fecal coliforms.

TABLE OF CONTENTS

INTRODUCTION 1

METHODS AND DESCRIPTIONS 2

RIVER WATER QUALITY

Routine Parameters 7

Metals 14

Pesticides & Herbicides 19

Nutrients 24

Bacteriological Indicators 30

SUMMARY 32

NORTH SASKATCHEWAN RIVER WATER QUALITY

INTRODUCTION

In order to provide an assessment of the impact of various development activities on surface waters in Alberta, the Water Quality Control Branch conducts a routine monitoring program on the more important systems. General water quality monitoring of the major rivers has been conducted since the 1950's, while monitoring for the more complex parameters such as metals and biocides was begun in the early 1970's.

The last report produced by Alberta Environment on the North Saskatchewan River water quality was in 1972 (Masuda 1972). Since then there have been a number of specific studies on the North Saskatchewan River, particularly in the Edmonton region:

> Stanley Associates examined the effect of a proposed weir on river water quality (Stanley Associates, 1975);
>
> The Edmonton Regional Utilities Study looked at water quality under various development scenarios (Alberta Environment, 1978); and
>
> a data summary was prepared by Water Quality Control Branch reviewing water quality data 1973-75 (Alberta Environment, 1975).

Biological water quality was addressed in two reports, Reynoldson (1973) and Reynoldson & Exner (in prep.). The impact of lime discharges from Edmonton water treatment plants and spring runoff in the Edmonton area, have also been examined (Reynoldson 1982, 1983) .

This report summarizes the quality of the mainstem North Saskatchewan River over the period 1970-1981, as described by Alberta Environment routine monitoring programs, and in particular compares

measured water quality with surface water objectives. A subsequent report will describe the detailed chemical characterization of the river in the Edmonton region for 1982 and 1983.

METHODS AND DESCRIPTIONS

The North Saskatchewan River is one of the major rivers in the Saskatchewan-Nelson system and forms part of the Hudson Bay drainage system. It is extensively used for domestic and industrial supply and for a number of recreational activities. In Alberta the major use is in the Edmonton region, but other municipalities from the mountains to the border are dependent on this river as a source of water. In addition, the river acts as a receiving water for treated industrial and municipal wastes. These discharges, along with diffuse sources of contamination such as agricultural and urban runoff, have the potential to reduce water quality in the North Saskatchewan and impair the resource value of the river.

The definition of instream water quality relied on the routine river monitoring data collected by Alberta Environment, Water Quality Control Branch and Environment Canada, Inland Waters Directorate. Detailed data are stored on the NAQUADAT water quality data storage and retrieval system and may be obtained upon request.

Water quality of the North Saskatchewan has been monitored at numerous locations along the river for varying periods of time. For this report, data from four sites spaced from above Edmonton, at Devon, to the Border are presented (Figure 1). These sites were chosen both for their capacity to define changes in quality above and below major contaminant inputs and for the continuity of sampling location.

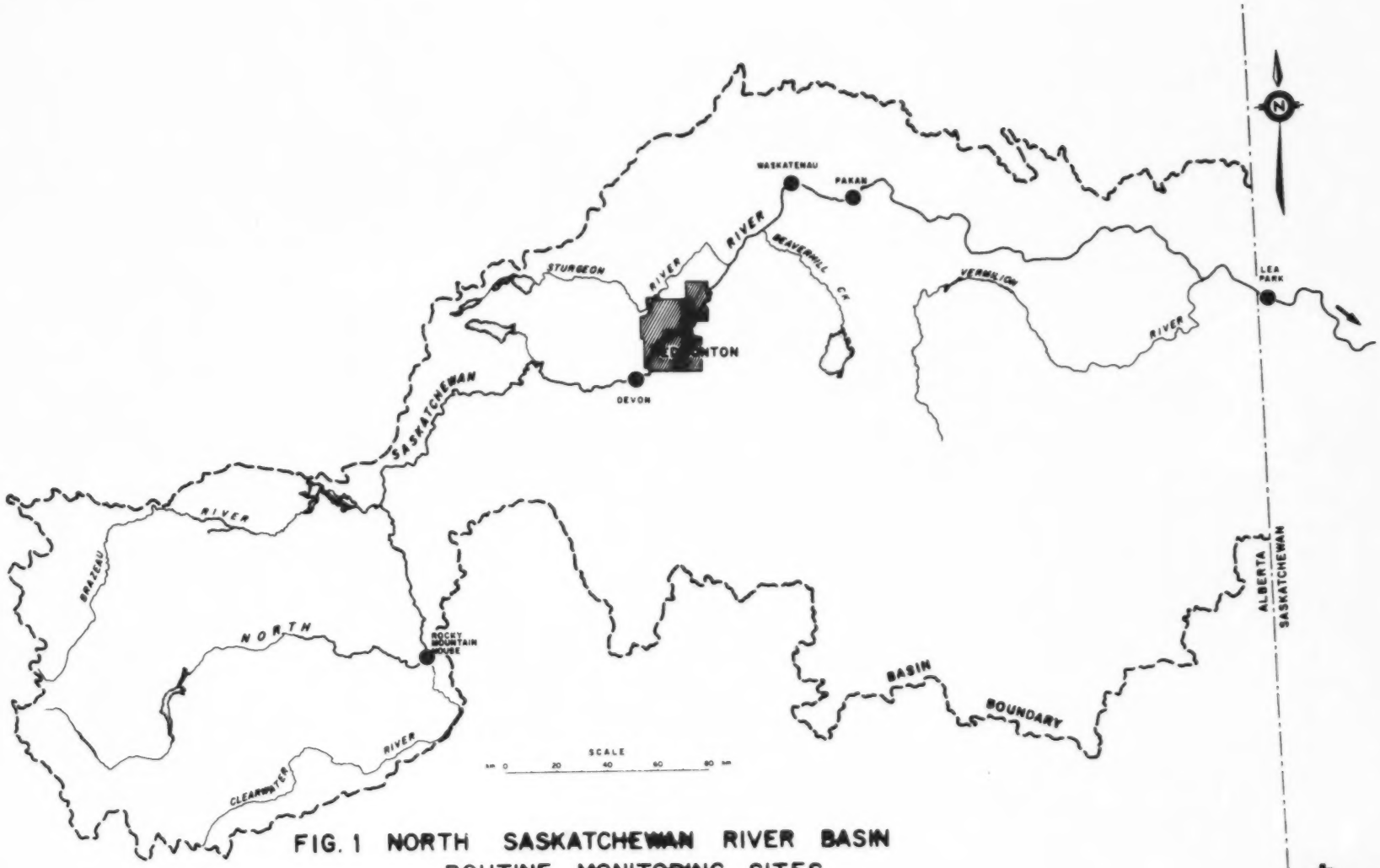

FIG. 1 NORTH SASKATCHEWAN RIVER BASIN
ROUTINE MONITORING SITES

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Data have been summarized separately for the periods 1970-77 and 1978-1981. This was necessitated by changes in monitoring practices and in order to identify major changes in quality over the decade. 1970 to 1977 results from Devon, Wasketenau and the Border are presented, together with 1977 to 1981 results from Devon, Pakan, and the Border. Data for each parameter have been presented as average and maximum values for the periods of study.

Season selection was based upon the river hydrograph (Figure 2) and the influence of biological activity. Winter is characterized as the period of lowest flow under ice cover, when little biological activity is occurring. Spring, which is the rising portion of the hydrograph, incorporates both local and mountain runoffs and is a period when the river carries the greatest sediment load. Biological activity in the river is commencing but is highly affected by both sediment transport and light inhibition. Summer is the declining portion of the hydrograph and the most active period of biological activity. Fall is also the declining portion of the hydrograph. Suspended sediment transport is low and biological activity is declining because of falling temperatures.

River discharge is characteristically Cordilleran, with peak flows during mid-June resulting from mountain snowmelt (Figure 2). The lowest discharge occurs during late fall and winter. Winter flows are consistently maintained near 100 m^3.sec (c.m.s.) by upstream regulation, whereas June-peak and summer discharges can vary considerably between years. During the 1970's, there were a number of years with reduced spring peaks and low summer flows, notably 1975, 1976 and 1979 (Figure 3).

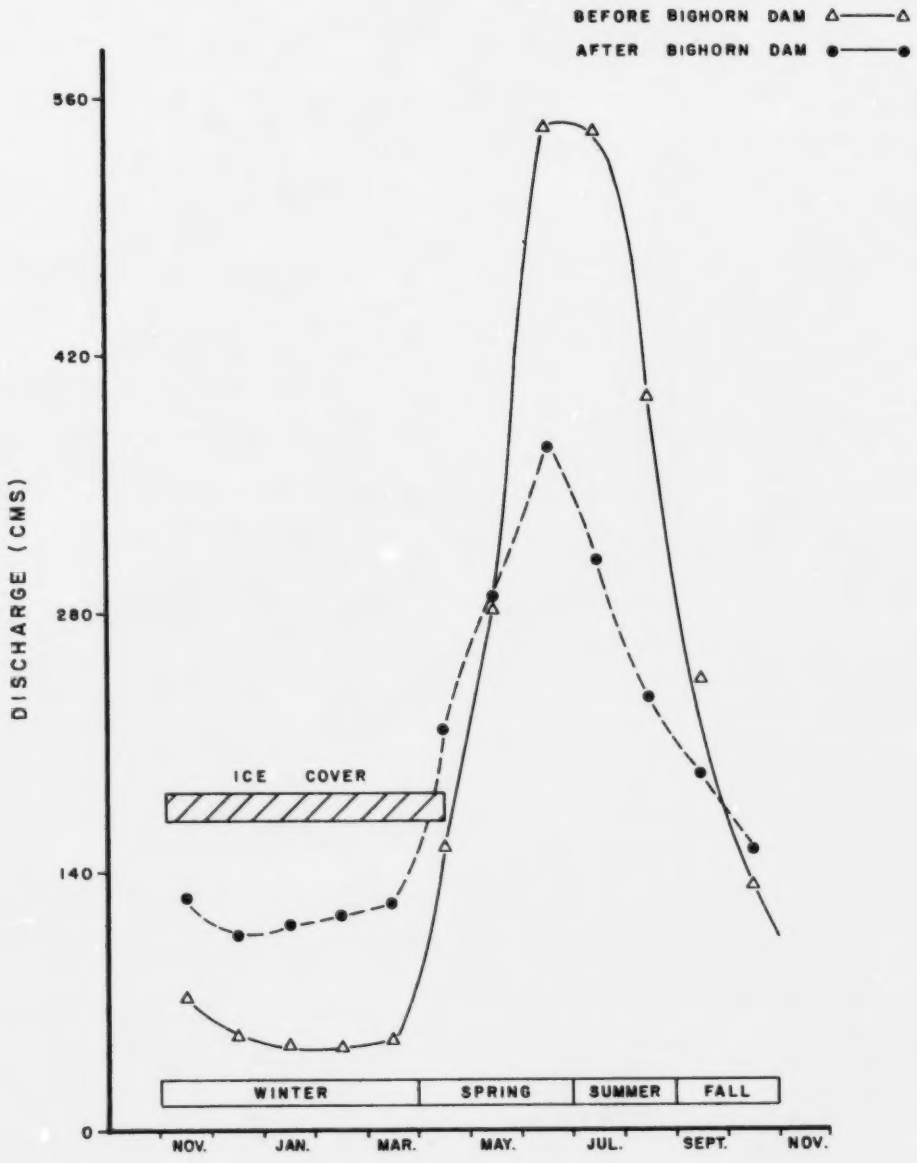

FIG. 2 AVERAGE MONTHLY FLOW IN THE NORTH SASKATCHEWAN RIVER AT EDMONTON.

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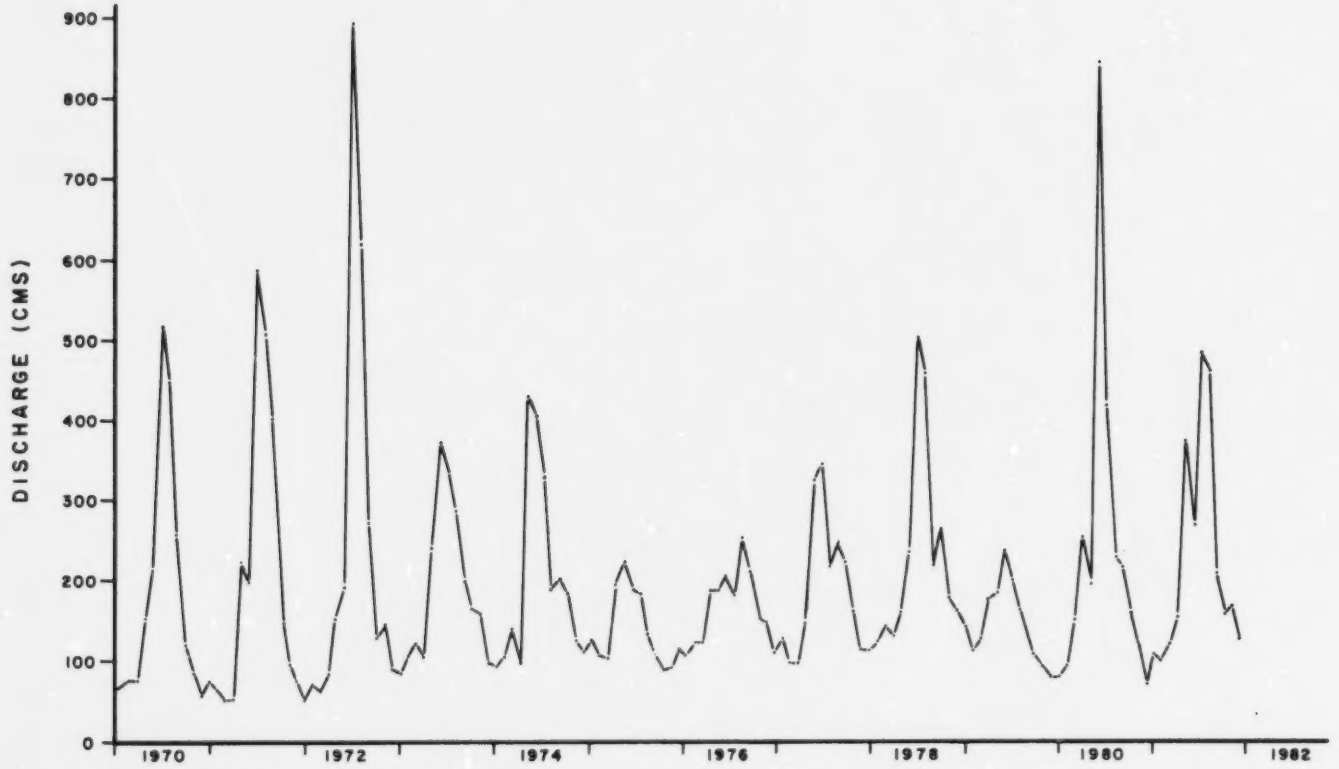

FIG. 3 MEAN MONTHLY DISCHARGE FOR NORTH SASKATCHEWAN RIVER AT EDMONTON (1970-1981)

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River discharge has a direct effect on water quality via dilution of contaminant inputs. Industrial and municipal effluent flow rates remain relatively constant; therefore, the after-mixing river concentration of a contaminant is largely dependent upon the amount of water into which the effluent is discharged. In the North Saskatchewan River, greatest dilution occurs at peak flow in June, and the least dilution are in the winter months. Consequently, the critical periods for waste-load assimilation are late summer, fall and winter. It is during these periods, when river contaminant concentrations are likely to be at a maximum, that the probability of limited utilization of the North Saskatchewan River in water quality terms is greatest.

The data are presented in this report as long-term averages and maximum values. The influence of stream discharge, other physical variables and biological factors on the more acute North Saskatchewan River water quality problems are currently being investigated and will be documented in upcoming reports.

NORTH SASKATCHEWAN RIVER WATER QUALITY

The average water quality of the North Saskatchewan River for the periods 1970 to 1977 and 1977 to 1981 is given for sites located longitudinally along the river from Devon to the Border (Figure 1). The data are presented and discussed by parameter group. A group is composed of parameters which are related or vary in a similar fashion.

ROUTINE PARAMETERS

This grouping includes the major inorganic ions, parameters related to suspended particulates and some organic constituents such as bio-chemical oxygen demand (BOD) and phenolic substances (Table 1).

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
ROUTINE PARAMETERS
TABLE 1.1

PARAMETER	Specific Conductance (us.cm)						Total Dissolved Solids (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	45	317	370	40	327	480	27	188	222			
Waskatenau	38	337	435	-	-	-	23	206	258			
Pakan	17	326	370	35	361	985	17	192	239			
border	33	374	525	38	337	417	15	210	311			
ASWO								500				

PARAMETER	pH						Total Alkalinity (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	low	high	n	low	high	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	65	7.2	8.8	29	7.6	8.4	59	140	180	21	123	153
Waskatenau	57	7.6	8.7	-	-	-	51	151	196	-	-	-
Pakan	17	7.8	8.7	26	7.4	8.6	17	139	162	21	134	384
border	54	7.6	8.9	39	7.1	8.9	54	155	219	22	131	160
ASWO		6.5 - 8.5										

PARAMETER	Phenol Alkalinity (mg.L)						Total Hardness (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	39	1.2*	6	37	0.1	2.5	16	171	211	42	161	202
Waskatenau	32	1.0*	8	-	-	-	15	182	248	-	-	-
Pakan	18	0.4*	L4	36	0.2*	5.1	-	-	-	42	176	543
border	31	2.6*	25	36	1.0	7.0	47	188	271	39	171	213
ASWO												

* statistics include less than or greater than values
L Less than
Note pakan sampled from 1976 onward.

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
ROUTINE PARAMETERS
TABLE 1.2

PARAMETER	Bicarbonate (mg.L) calculated						Carbonate (mg.L) calculated					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	39	159*	191	21	149	187	39	1*	7	37	0	3
Waskatenau	32	173*	215	-	-	-	32	1*	10	-	-	
Pakan	17	169*	197	21	163	468	17	1*	5	36	0*	6
border	31	166*	217	21	155	195	31	3*	30	36	1	8
ASWO												

PARAMETER	Sulphate (mg.L)						Chloride (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	58	46	83	42	35	45	64	2.0*	20	42	1.3	8.3
Waskatenau	47	48*	85	-	-	-	56	6.5*	20	-	-	
Pakan	17	52	68	42	43	178	17	2.5*	9	42	3.5	14.0
border	54	55	89	39	41	54	54	13.8*	65	39	5.3	9.0
ASWO			500						250			

PARAMETER	Fluoride (mg.L)						Calcium (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	51	L0.1	L0.2	36	0.1	0.2	40	45	61	42	43	55
Waskatenau	37	0.2	0.3	-	-	-	15	49	61	-	-	-
Pakan	17	0.2	0.2	36	0.1	0.3	17	45	51	42	47	122
border	53	0.2	0.4				15	49	80	39	45	56
ASWO			1.5									

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
ROUTINE PARAMETERS
TABLE 1.3

PARAMETER	Magnesium (mg.L)						Sodium (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	47	14	33	42	13	16	48	4.1	18	42	4.1	7.1
Waskatenau	39	15	25	-	-	-	40	7.8	16	-	-	-
Pakan	17	14	20	42	14	58	17	7.3	10	42	7.6	27.0
border	34	15	23	39	14	18	35	11.3	28	39	9.4	17.0
ASWO												

PARAMETER	Potassium (mg.L)						Silica (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	47	0.8	3.7	42	0.9	3.5	13	3.8	4.2	38	4.4	7.5
Waskatenau	40	1.1	3.0	-	-	-	-	-	-	-	-	-
Pakan	17	1.0	2.7	42	1.5	5.0	5	3.1	4.0	39	5.0	38
border	35	1.6	4.4	39	1.6	5.1	5	2.8	4.4	39	3.3	6.4
ASWO												

PARAMETER	Turbidity (J.T.U.)						Non Filterable Residue (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	60	8	57	36	15	104	16	96*	276	41	36*	590
Waskatenau	49	8*	39	-	-	-	18	100	170	-	-	-
Pakan	11	8	12	37	15	106	2	130	176	41	32*	162
border	48	9	52	37	20	285	9	94*	400	32	37*	781
ASWO												

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
ROUTINE PARAMETERS
TABLE 1.4

PARAMETER	Colour (relative units)						Total Organic Carbon (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon				39	16*	70	28	7.4*	20	15	3.1*	8.0
Waskatenau				-			25	20.5*	253	-		
Pakan				39	22*	120	13	6.6*	14	15	4.3	11.0
border				37	32*	500	14	10.5*	22	13	4.4*	11.0
ASWO												

PARAMETER	Total Inorganic Carbon (mg.L)						Phenolic Materials (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	28	25	38	5	30	32	71	0.003*	0.015	42	0.002*	0.010
Waskatenau	25	22	33	-	-	-	64	0.004*	0.027	-	-	
Pakan	13	22	29	6	30	32	12	0.002*	0.004	42	0.002*	0.012
border	14	23	32	5	32	35	53	0.005*	0.060	38	0.002*	0.009
ASWO										0.005		

PARAMETER	Oil & Grease (mg.L)						Biochemical Oxygen Demand (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	42	1.3*	4.1	-	-	-	72	1.1*	6.0	-	-	-
Waskatenau	31	1.3*	3.5	-	-	-	64	2.3*	7.0	-	-	-
Pakan	-	-	-	-	-	-	13	1.9*	3.6	-	-	-
border	39	2.1*	20.0				52	1.9*	5.3	11	2.1	3.1
ASWO												

As the bedrock of the North Saskatchewan River Basin is a sandstone-shale complex, the river has a high alkalinity and an almost neutral pH. Surface water throughout the basin is classified as hard to very hard, as indicated by total hardness concentrations with average values exceeding 160 mg.L (McNeely et al, 1979).

The major dissolved salt in the river is calcium bicarbonate, with magnesium sulphate of secondary importance. Total salt concentrations, as measured by specific conductance, and total dissolved solids did not show any major change moving in a downstream direction.

The salt concentrations in the river remained well within Alberta Surface Water Objectives (A.S.W.O.) (Alberta Environment, 1977). Appreciable differences in major ion chemistry before and after 1977 are not apparent.

The quantity of suspended particulate material in the water is measured by turbidity and non-filterable residue (NFR) tests. This material includes clay, silt and sand particles, together with some suspended organic matter. Average turbidity did not increase in the river moving downstream. NFR values for 1970 and 1977 increased from Devon to the Border; however, the data were limited and the trend did not repeat from 1977 to 1981. Natural geologic and topographic transitions from the foothills to the parkland region caused increases due to increased soil erosion potential. Tributary streams that flow through agricultural areas may also have contributed significant quantities of suspended particles to the river.

The ability of a river to transport suspended particulate materials is directly related to stream discharge levels. Consequently, the turbidity of the North Saskatchewan River is greatest during June and

early July, when flows are highest, and lowest during fall and winter. Average 1977 to 1981 NFR values near the Mouth were less than the 1970 to 1975 means. This may be due to the series of low flow years during the late 1970's.

Colour, a measure of water clarity irrespective of suspended particulate material, was low overall with some increase in the reaches below Edmonton. Average values were generally less than the level at which visual detection of colour is possible (McNeely et al, 1979).

Total inorganic carbon showed no trend with distance downstream, however, total organic carbon did increase slightly. This increase was probably due to biological activity in the river and effluent discharges particularly treated sewage, from Edmonton. It is also of note that values downstream of Edmonton in the latter part of the decade were a little lower.

Phenolic compounds at very high concentrations can be toxic to fish. At low levels they can cause fish tainting and taste problems in chlorinated public water supplies. As a consequence, the Alberta Surface Water Objectives and Canadian Drinking Water Guidelines (C.D.W.G.) (Health and Welfare Canada, 1978) are set very low. Sources of phenol include industries, municipal wastes and decaying aquatic plants and algae. The 1970 to 1977 and 1977 to 1981 data for the North Saskatchewan River indicated relatively low levels compared to the A.S.W.O. and C.D.W.G and, while average values were lower than A.S.W.O., maximum values both upstream and downstream have exceeded the objective concentrations. Average phenolic concentrations near the Border showed some slight reduction in the second part of the decade.

METALS

During the 1970's, data for 18 metals were obtained from the routine monitoring program. All the data are summarized in Tables 2.1 to 2.3, but discussion is restricted to those that show apparent trends. Of the 18 metals, Arsenic, Barium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver and Zinc showed no longitudinal trends in the river.

Aluminum concentrations, both average and maximum values, increased downstream of Edmonton, yet remained within the normal surface water range of less than 1.0 mg.L (1000 ug.L) (McNeely et al, 1979). There are no surface water guidelines for aluminum as it is not of public health significance. Cultural inputs at Edmonton, from the water treatment plant processes, are probably the major contributors to the elevated values found downstream.

Arsenic concentrations neither exceeded the A.S.W.O. maximum concentrations for any sample taken in the river over the eleven year period, nor was there any downstream trend indicating inputs or change in the early or late part of the decade.

Barium similarly showed no trends or changes in the river above or below Edmonton and concentrations were an order of magnitude, below objectives.

Boron did show some longitudinal increase, but at all sites average boron concentrations remained one order of magnitude below A.S.W.O. maximum concentrations. The observed trend for boron can be attributed to erosion and dissolution from naturally occurring sedimentary materials.

Cadmium was barely detectable in the samples with the exception of one value in the 1970 to 1977 period at Devon. This is not considered

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
METALS
TABLE 2.1
(all values µg.L)

PARAMETER	Aluminum (ext)						Arsenic (dis)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	-	-	-	9	94	170	6	0.6*	1.5	9	0.5*	0.5
Waskatenau	-	-	-	-	-	-	-	-	-	-	-	-
Pakan	-	-	-	8	130	400	8	0.6*	2.0	9	0.5*	0.5
border				29	134	840	8	0.9	1.5	30	0.6*	1
ASWO								10				
CDWG								50				

PARAMETER	Barium (ext)						Boron (dis)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	-	-	-	6	100*	100	-	-	-	24	40*	60
Waskatenau	-	-	-	-	-	-	-	-	-	-	-	-
Pakan	-	-	-	5	100*	100	-	-	-	23	50*	140
border	-	-	-	24	100*	100				35	50	110
ASWO					1000						500	
CDWG					1000							

PARAMETER	Cadmium (tot)						Chromium (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	18	3*	25	5	1*	1	19	2*	5	9	L15	L15
Waskatenau	13	1*	2	-			11	3*	6	-		
Pakan	-	-	-	4	1*	1	13	4*	13	8	L15	L15
border	15	1*	4	24	1*	1	15	3*	14	16	L15	L15
ASWO		10									50	

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
METALS
TABLE 2.2
(values in µg.L)

PARAMETER	Cobalt (ext)						Copper (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	19	2*	13	9	2*	3	19	4*	11	9	3*	8
Waskatenau	11	5*	9	-	-	-	11	4*	9	-	-	-
Pakan	13	1*	2	8	2*	2	13	5*	12	8	2*	5
border	15	1*	5	23	2*	3	15	5*	12	27	2*	4
ASWO									20			

PARAMETER	Iron (dis)						Iron (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	-	-	-	14	50*	110	31	370	3440	9	215	520
Waskatenau	-	-	-	-	-	-	24	383*	1900	-	-	-
Pakan	-	-	-	15	50*	80	17	259*	1150	8	216	580
border				11	50*	90	19	267	1080	28	368	2500
ASWO									300			

PARAMETER	Lead (tot)						Manganese (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	8	8*	37	5	4*	4	19	28*	161	9	10*	20
Waskatenau	11	2*	6	-	-		-	-	-	-	-	-
Pakan	13	4*	8	4	L4	L4	13	27*	100	8	20	50
border	15	4*	10	11	4*	8	15	30*	31	28	30*	120
ASWO			50						50			

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
METALS
TABLE 2.3
(all values in µg.L)

PARAMETER	Mercury (tot)						Molybdenum (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	36	0.3*	1.2	23	0.02*	0.08	11	L1	L1	9	L100	L100
Waskatenau	24	0.3*	1.0	-	-		-	-	-	-	-	-
Pakan	12	L0.1	L0.1	20	0.02*	0.03	11	L1	L1	7	L100	L100
border	30	0.3*	2.5	23	0.02*	0.05	11	L1	L1	-	-	-
ASWO			0.1									

PARAMETER	Nickel (ext)						Selenium					
							(tot)			(dis)		
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	19	3*	16	9	2*	5	4	10*	20	21	0.5*	0.5
Waskatenau	11	6	13	-	-	-	3	8*	10	-	-	-
Pakan	13	4*	14	8	4	7	-	-	-	23	0.6*	1.1
border	15	4*	6	8	3*	6	3	8*	10	36	L0.5	L0.5
ASWO									10			

PARAMETER	Silver (ext)						Zinc (ext)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	12	L1	L1	8	L4	L4	17	33*	L100	4	4	7
Waskatenau	-	-	-	-	-		12	20*	68	-	-	-
Pakan	11	L1	L1	5	3*	L4	12	18*	L100	4	7	11
border	11	L1	L1	6	L4	L4	13	28	100	10	14*	87
ASWO			50						50			

to be of significance. The average values were well below the surface water objectives.

Iron levels, although showing no increase downstream, did exceed the A.S.W.O. concentrations for the extractable form. The guidelines were established for aesthetic reasons as high iron concentrations in domestic water supplies can discolor clothes and plumbing fixtures, and encrust pipes. Iron concentrations increased naturally along the watercourse due to weathering of bedrock material and groundwater input, which has naturally high concentrations.

Manganese maximum concentrations also on occasion exceeded the A.S.W.O. although, with the exception of Wasketenau in the 1970 to 1977 period, average values did not. As with iron, the guidelines have an aesthetic and economic basis since manganese may impart taste as well as stain fabric and porcelain at quite low concentrations. Manganese is naturally derived from soils, river sediments and sedimentary rocks. Managanese may be taken up by plant growth and, therefore, may vary considerably on a seasonal basis.

Lead, nickel and zinc were detected in the system but at trace levels. Between site means were very similar. The maximum concentrations of both lead and zinc were found at the downstream sites. Average and maximum concentrations of lead were well below A.S.W.O. concentrations. Values for the period 1970 to 1977 for zinc were considerably higher. This reflects a less sensitive analytical technique in the period as detection limits were much higher. In the period 1977 to 1981, the objective was not exceeded by the average values. On occasion, the objective was exceeded by maximum values at the border. This result suggests a natural increase.

Mercury, in the period 1977 to 1981, was well below A.S.W.O. concentrations and showed no longitudinal trend. In the period 1970 to 1977, the analytical detection limit (0.1 ug/L) was higher, but maximum values were also greater, even upstream. This suggests mercury concentrations may in fact have been higher in the river in the early part of the decade.

PESTICIDES & HERBICIDES

Monitoring for a total of 24 pesticides and herbicides was begun on the North Saskatchewan River in 1978. Of those, only seven were detected in the water samples above the limit of analytical precision and only two, alpha BHC and 2,4-D, measured routinely (Table 3). Similar observations have been made for the Bow River in the same period (Hamilton 1983).

Of the pesticides, the organochlorine compounds are the most resistant to degradation and, therefore, persist the longest in the environment. Of the various organochlorine insecticides tested for in the North Saskatchewan River, only alpha and gamma BHC have been detected. Gamma BHC, commonly known as lindane, was measured on one occasion at Devon, two occasions at Pakan and more frequently (30%) at the Border. Its maximum observed concentration of 0.004 ug/L well below the C.D.W.G. maximum allowable concentration of 4 ug/L.

Alpha BHC is commonly found throughout the North Saskatchewan River, with similar average concentrations at all three sites (maximum 0.010 ug/L). Unlike lindane, it has no insecticidal characteristics and is only present as an impurity in certain pesticide formulations (Gummer, 1979). Prior to 1976, a pesticide of mixed BHC isomers

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
PESTICIDES & HERBICIDES
TABLE 3.1
(all values in µg.L - p.p.b)

PARAMETER	P,P - DDT			P,P - DDD			P,P - DDE			P,P - Methoxychlor		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	14		L0.004	14		L0.002	14		L0.001	14		L0.01
Waskatenau	-		-	-		-	-		-	-		-
Pakan	13		L0.004	13		L0.002	13		L0.001	13		L0.01
border	33		L0.004	33		L0.002	33		L0.001	33		L0.01
CDWG	30			30			30			100		

PARAMETER	Heptachlor			Heptachlor Epoxide			Alpha-Endo Sulfan			Beta-endo Sulfan		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	14		L0.001	14		L0.002	14		L0.001	14		L0.003
Waskatenau	-		-	-		-	-		-	-		-
Pakan	13		L0.001	13		L0.002	13		L0.001	13		L0.003
border	33		L0.001	33		L0.002	33		L0.001	33		L0.003
CDWG	3			3								

PARAMETER	Alpha-Chlordane			Gamma-Chlordane			Gamma-BHC (Lindane)			Alpha-BHC		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	14		L0.003	14		L0.002	14	0.001*	0.001	14	0.004*	0.007
Waskatenau	-		-	-		-	-	-	-	-	-	-
Pakan	13		L0.003	13		L0.002	13	0.001*	0.002	13	0.004*	0.010
border	33		L0.003	33		L0.002	34	0.001*	0.004	34	0.004*	0.008
CDWG	7						4					

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
PESTICIDES & HERBICIDES
TABLE 3.2
(all values in µg.L - p.p.b)

PARAMETER	Aldrin			Endrin			Dieldrin			Aroclor 1254 (PCB's)		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	14		L0.001	14		L0.002	14		L0.002	14		L0.002
Waskatenau	-		-	-		-	-		-	-		-
Pakan	13		L0.001	13		L0.002	13		L0.002	13		L0.002
border	33		L0.001	34		L0.002	33		L0.002	34		L0.002
CDWG		0.7			0.2			0.7				

PARAMETER	Aroclor 1248 (PCB's)			Aroclor 1260 (PCB's)			Aroclor Total (PCB's)			2,4 - D		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	13		L0.002	14		L0.005	6		L0.020	15	0.007*	0.04
Waskatenau	-		-	-		-	-		-	-	-	-
Pakan	12		L0.002	13		L0.005	6		L0.020	12	0.190	0.60
border	32		L0.002	34		L0.005	13		L0.020	36	0.172*	0.70
CDWG											100	

PARAMETER	2,4,5 - T			MCPA			2,4 - DB			2,4 - DP		
PERIOD	1978-81			1978-81			1978-81			1978-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	14	0.003*	0.02	14		L0.2	15		L0.009	15	0.004*	0.01
Waskatenau	-	-	-	-		-	-		-	-	-	-
Pakan	11	0.013*	0.04	12		L0.2	12		L0.009	12	-	L0.004
border	36	0.012*	0.05	31	0.21*	0.6	32	0.01*	0.03	33	0.006*	0.060
CDWG		10										

containing 60% to 70% alpha was marketed. Lindane is the only BHC isomer currently marketed, and it contains only 1% alpha as impurity. Gummer (1979), in his prairie-wide review of herbicides and pesticides, noted widespread presence of alpha BHC even in remote watersheds. He concluded that the presence of alpha BHC in pristine waters must be due to volatilization, atmospheric transport and redeposition.

Amongst the herbicides, 2,4-D is found consistently in the North Saskatchewan, while 2,4-DP and 2,4,5-T are rarely found. Amongst the chlorophenoxy acid herbicides, 2,4-D and MCPA account for 90% of the total herbicides used in western Canada (Gummer, 1979). The maximum concentration of 2,4-D observed was 0.7 ug/L, which again is well below the C.D.W.G. maximum allowable concentration. It did, however, increase in average concentration with distance downstream (Figure 4). There is an obvious seasonal pattern, best illustrated at the Border station by the occurrence of 2,4-D in the river.

A concentration of 1.0 ug/L has been proposed as the level at which aquatic biological communities are effected (Gummer, 1979). Sources of 2,4-D along the North Saskatchewan River would include agricultural drainage, urban runoff and municipal effluents. The marginal use of 2,4-DP (relative to 2,4-D) may account for its low frequency of detection (Gummer, 1979).

The Arocolor compounds are polychlorinated biphenols (PCBs), compounds which have received much public attention. In the past, Arocolor 1248 has commonly been used as a component of electrical transformer oil but its use is currently restricted. As older transformers are phased out, its frequency of observation in the environment should become less. The data do not indicate these materials were present in the North Saskatchewan River.

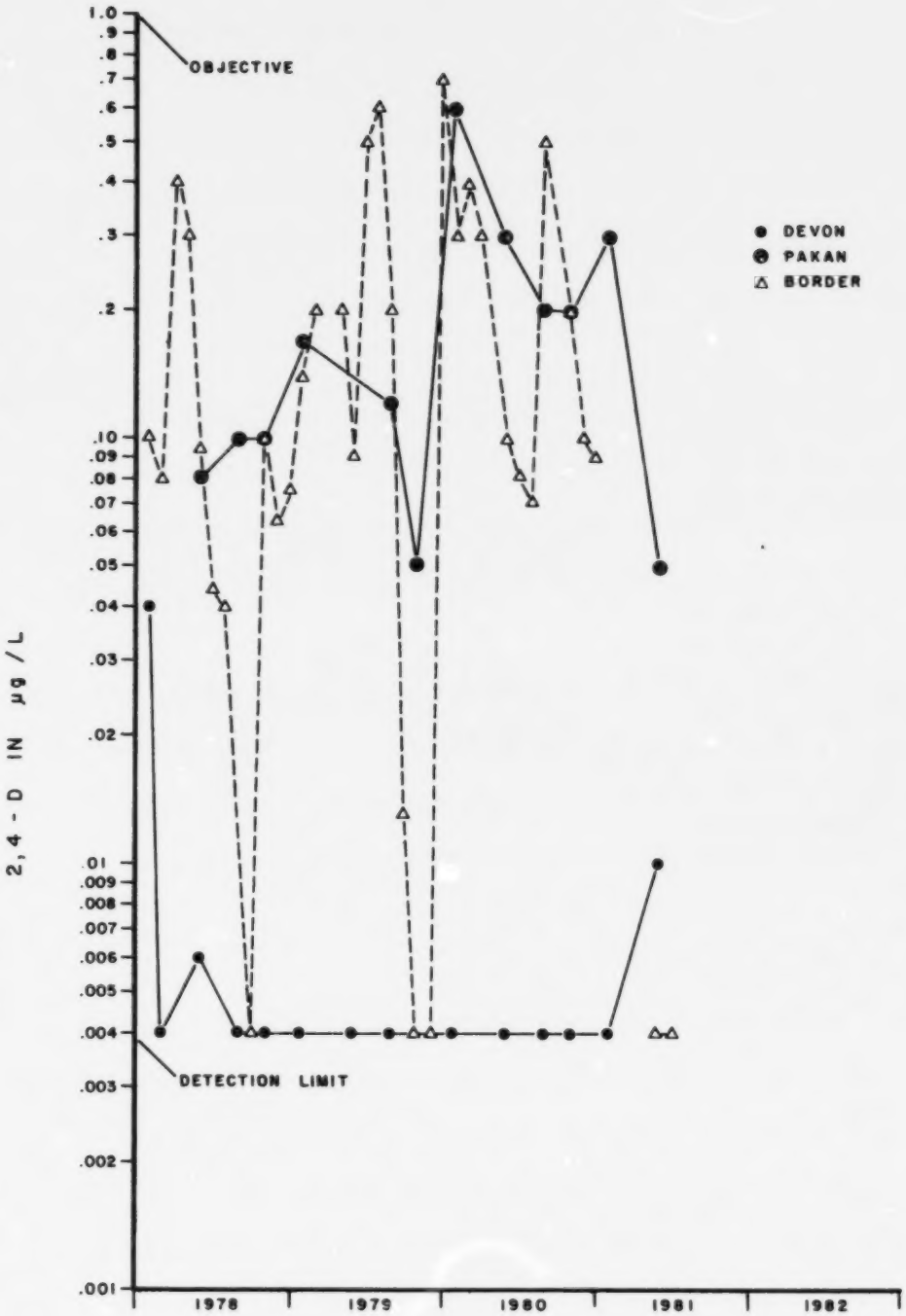

FIG. 4 2,4 - D CONCENTRATION IN THE NORTH SASKATCHEWAN RIVER.

Alberta
ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

As with metals, many organic residues tend to disappear rapidly from the water phase through adsorption to sedimentary material or bio-uptake and accumulation. Consequently, non-occurrence of an organic residue in a water sample may not imply complete non-existence in the environment. Ongley and Blachford (1982) were able to detect residues of certain organochlorine compounds, which were not identifiable in corresponding raw water sampleson the suspended sediments of the lower Bow River.

These included 1-3-5, 1-2-4 and 1-2-3 chlorobenzenes; alpha and beta BHC; alpha chlordane; dieldrin and its metabolites and PCB compounds. However, even on the sedimentary material, residue concentrations were still at or very near the limits of chemical detection.

For both heavy metals and organic residues, Ongley's work indicated classical water sampling techniques although required for comparison to water quality objectives and guidelines, do not always show levels of certain reactive compounds in a receiving waterbody.

NUTRIENTS

Phosphorus is most often considered the nutrient controlling aquatic plant growth. Data for two forms of phosphorus are presented in Table 4: dissolved ortho-phosphate, which is a measure of the major dissolved inorganic form of phosphate phosphorus; and total phosphorus.

Total phosphorus was high at all four stations in both periods, and average values exceeded the objective of 50 ug/L at all sites. Two further points are noteworthy: values were higher downstream of Edmonton. Two that values are considerably higher in the early part of

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
NUTRIENTS - NITROGEN & PHOSPHORUS
TABLE 4.1

PARAMETER	Total Phosphorus (µg.L)						Dissolved Ortho Phosphate (µg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	31	110*	450	41	60*	740	29	12*	33	19	3*	8
Waskatenau	28	160	420	-	-	-	25	55	190	-	-	-
Pakan	13	180*	750	42	124*	340	13	49	219	19	45	110
border	14	150*	400	39	109	650	15	99*	800	-	-	-
ASWO		50										

PARAMETER	Total Nitrogen (mg.L)						Total Kjedahl Nitrogen (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	31	0.41*	1.44	38	0.18	0.88	31	0.3*	1.2	5	0.2*	0.4
Waskatenau	28	0.95*	1.84	-	-	-	28	0.7	1.6	-	-	-
Pakan	13	0.77*	1.49	37	0.80	3.8	13	0.6	1.4	5	0.6	0.8
border	14	0.89*	1.77	39	0.60	1.6	14	0.6*	1.2	6	0.6	1.0
ASWO		1.00										

PARAMETER	Ammonia (mg.L)						Nitrate & Nitrite (mg.L)					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
Devon	64	0.19*	1.0	35	0.10*	0.2	29	0.12	0.72	28	0.05*	0.16
Waskatenau	63	0.72*	1.7	-	-	-	25	0.29	0.48	-	-	-
Pakan	13	0.25*	0.6	31	0.31*	1.1	12	0.20	0.49	26	0.24	0.62
border	54	0.67*	1.9	-	-	-	11	0.31*	1.06	28	0.35*	0.74
ASWO												

the decade. The upstream/downstream of Edmonton differences were even more marked in the case of dissolved ortho-phosphate. It is evident from these data that there is a major input of phosphorus, particularly of the dissolved form in the Edmonton area. The most likely source of this input is the Gold Bar sewage treatment plant.

There is a major seasonal pattern to the occurrence and form of phosphorus in the North Saskatchewan River (Table 4.2). Dissolved ortho-phosphate showed major downstream differences, and at Pakan Bridge the summer concentrations were lowest when uptake by plant material was occurring. In the fall and winter the plants die and concentrations increase. The high spring values are associated with very high flows and the input of runoff from the watershed.

The importance of runoff and the high sediment load in the river is shown by the behaviour of total phosphorus. Values were greatest in the spring or summer. This, it is considered, was primarily particulate phosphorus.

Phosphorus concentration in drinking water is of no public health concern.

Like phosphorus, nitrogen concentrations in the North Saskatchewan River increased downstream of Edmonton. Inorganic nitrogen forms include ammonia, nitrate and nitrite. In water with adequate oxygen, ammonia is converted to nitrate through a process of nitrification. Nitrite is an intermediate compound which is unstable and rapidly converted to nitrate. Total nitrogen is a measure of both inorganic and organic forms of nitrogen. Total kjeldahl nitrogen is a measure of total organic nitrogen plus ammonia.

NORTH SASKTACHEWAN RIVER
WATER QUALITY DATA
SEASONAL VARIATION IN PHOSPHORUS FORM (1977-81)
TABLE 4.2
(μ g.L)

Dissolved Ortho-phosphate

	spring	summer	fall	winter
Devon	5	L3	L3	L3
Pakan	73	24	51	51
Border	-	-	-	-

Total Phosphorus

	spring	summer	fall	winter
Devon	115	116	13	29
Pakan	239	118	95	94
Border	173	133	56	74

Total nitrogen increased considerably downstream of Edmonton; although average values were less than the A.S.W.O. of 1.00 mg.L, maximum values did exceed the objective.

The distribution of nitrogen forms varies considerably by season (Table 4.3). In winter, total nitrogen concentrations downstream of Edmonton were much higher, whereas upstream there is little apparent seasonal difference and values were low. Winter ammonia is the major component downstream, this is the major form discharged by sewage treatment plants and found in industrial effluents. Its lower occurrence in summer, and the switch to nitrate-nitrite as the dominant form, reflects more rapid nitrification at warmer summer temperatures.

The seasonal differences are due to a number of factors including greater effluent dilution by higher summer discharge rates, higher water temperatures, uptake of both ammonia and nitrate ions by aquatic plants and loss of ammonia to the atmosphere during the ice-free season. Finally, degradation of any organic nitrogen input to the river is more rapid during warm temperature periods. Organic nitrogen is converted by bacteria to inorganic ions, which can be taken up by aquatic plants.

The North Saskatchewan River exceeds the A.S.W.O. for total nitrogen below Edmonton on occasion during the winter months but, although nitrate concentrations are high in the lower part of the river compared to upstream, the Canadian Drinking Water Guidelines maximum allowable concentration is 10.0 mg/L and has not been exceeded.

There is no drinking water or surface water objective for ammonia, however, high concentrations of disassociated ammonium ion can be toxic to fish. Based on the apparent condition of fish populations in the North Saskatchewan River, ammonia toxicity is not considered a problem.

NORTH SASKATCHEWAN RIVER
SEASONAL DISTRIBUTION OF NITROGEN FORMS (1977-81)
TABLE 4.3
(mg.L average values)

	DEVON		PAKAN		BORDER	
	winter	summer	winter	summer	winter	summer
Organic (by difference)	–	–	0.24	0.07	-	-
Inorganic - ammonia	L0.1	L0.1	0.43	0.12	-	-
- nitrite-nitrate	0.07	0.02	0.20	0.27	0.42	0.21
Total	0.15	0.17	0.87	0.46	0.77	0.32

BACTERIOLOGICAL INDICATORS

The common pathogenic diseases transmitted through surface waters include dysentry, cholera, typhoid, gastroenteristis, infectious hepatitis, poliomyelitis and diarrhea. Sources of these organisms are infected people and animals. As such, these organisms can be introduced into sewage systems from homes, hospitals and industrial operations (i.e. animal handling, slaughtering) , as well as agricultural runoff contaminated with animal wastes.

Since direct monitoring of most pathogens in rivers or lakes is not feasible, indirect indicators of microbial safety are used. The philosophy of an indicator is that if it can be shown fecal contamination of a water has occurred, then pathogenic organisms may be present. However, detection of the indicator does not confirm a pathogen is actually being transmitted (McNeely et al, 1979).

Members of the coliform group of bacteria are the most commonly used microbiological indicators. The total coliform test measures gram-negative, non-spore forming, rod-shaped bacteria which are prolific in the intestinal tract of warm-blooded animals. Fecal coliforms include only those bacteria which grow at 44.5°C and are capable of fermenting sugar. Although both total and fecal coliform limits are usually included in water quality objectives, the latter is considered the more significant as it discounts the detection of coliform bacteria of non-fecal origin.

The objective in finished water for domestic supply is zero total or fecal coliforms. In raw surface waters, the objectives vary by use (Alberta Environment, 1977). In waters to be used for domestic supply after treatment or for non-contact recreation (2°), 90% of samples over

NORTH SASKATCHEWAN RIVER
WATER QUALITY DATA
MICROBIOLOGICAL
TABLE 5.1

PARAMETER	Total Coliforms MPN No. 100 mL						Faecal Coliforms MPN No. 100 mL					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
devon	54	98	1600	35	51	500	54	20	170	37	6*	66
waskatenau	56	5512*	92000	-	-	-	56	1547*	24000	-	-	-
pakan	11	8267	54000	34	2487	8100	11	785	2400	36	413*	1931
border	51	253*	G1800	39	150*	2000	51	31	350	39	48*	600
ASWO 2°		5000						1000				
1°		1000						200				

PARAMETER	Faecal Streptococci MF No. 100 mL						Std Plate Count No. mL					
PERIOD	1970-77			1977-81			1970-77			1977-81		
	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max	n	$\bar{x}$	max
devon	-	-	-	15	20*	100	36	4281	55000	-	-	-
waskatenau	-	-	-	-	-	-	33	21555*	300000	-	-	-
pakan	-	-	-	15	120*	480	-	-	-	-	-	-
border				-	-	-	35	36827	570000			
ASWO												

a 30-day period should have total coliforms of less than 5000/100 mL and fecal coliforms of less than 1000/100 mL. Water for direct contact recreation or vegetable crop irrigation (1°) should have less than 1000/100 mL total coliforms and 200/100 mL fecal coliforms as geometric averages of at least five samples in 30 days. These limits should not be exceeded in more than 20% of the samples and a limit of 2400/100 mL should not be exceeded on any one day.

Table 5 presents results of the routine monthly monitoring at Devon, upstream of Edmonton, and for two sites downstream of Edmonton. Although these data do not comply with the objective requirement of five samples over a 30-day interval, they do indicate long-term average values. Mean and range values above Edmonton meet all surface water objectives over the period 1970 to 1981 for faecal coliforms. One total coliform value in 1971 exceeded the objective. At the border, average values also met all surface water objectives, although upper range values have on occasion exceeded 1° contact objectives.

At Pakan, average values for total coliforms exceeded both objectives, and average faecal coliforms exceeded 1° contact objectives.

SUMMARY

The North Saskatchewan River is one of the major rivers in Alberta and of considerable economic and historical significance. The major developments are restricted to 50-kilometer reach of the river, between the upstream municipal boundry of Edmonton and Fort Saskatchewan.

Over the period of 1970 to 1981, a review of water quality monitoring data shows the main impacts on water quality derive from municipal effluents, with increases in phosphorus and nitrogen forms,

and microbiological indicators demonstrating the major change. Over the eleven year period these parameters were the ones that most consistently exceeded surface water objectives downstream of Edmonton.

Of the metal parameters, iron and manganese also exceeded objectives at maximum levels. This is considered a natural phenomenon as there were no longitudinal changes and the exceedence was as frequent upstream of Edmonton. One value in the eleven year period for both cadmium and selenium exceeded objectives on both occasions at Devon. This is not considered significant, and in the case of Cadmium, is most likely an aberrant data point.

In comparing the early and latter part of the decade, there is indication of improving water quality based on lower levels of the nutrient and microbiological indicators. Certainly, there is no evidence of any deterioration in water quality over the period based on these data.

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